ATLAS TDAQ Upgrade

WBS 4.6

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US Program Managers Review: February 7, 2012

Outline

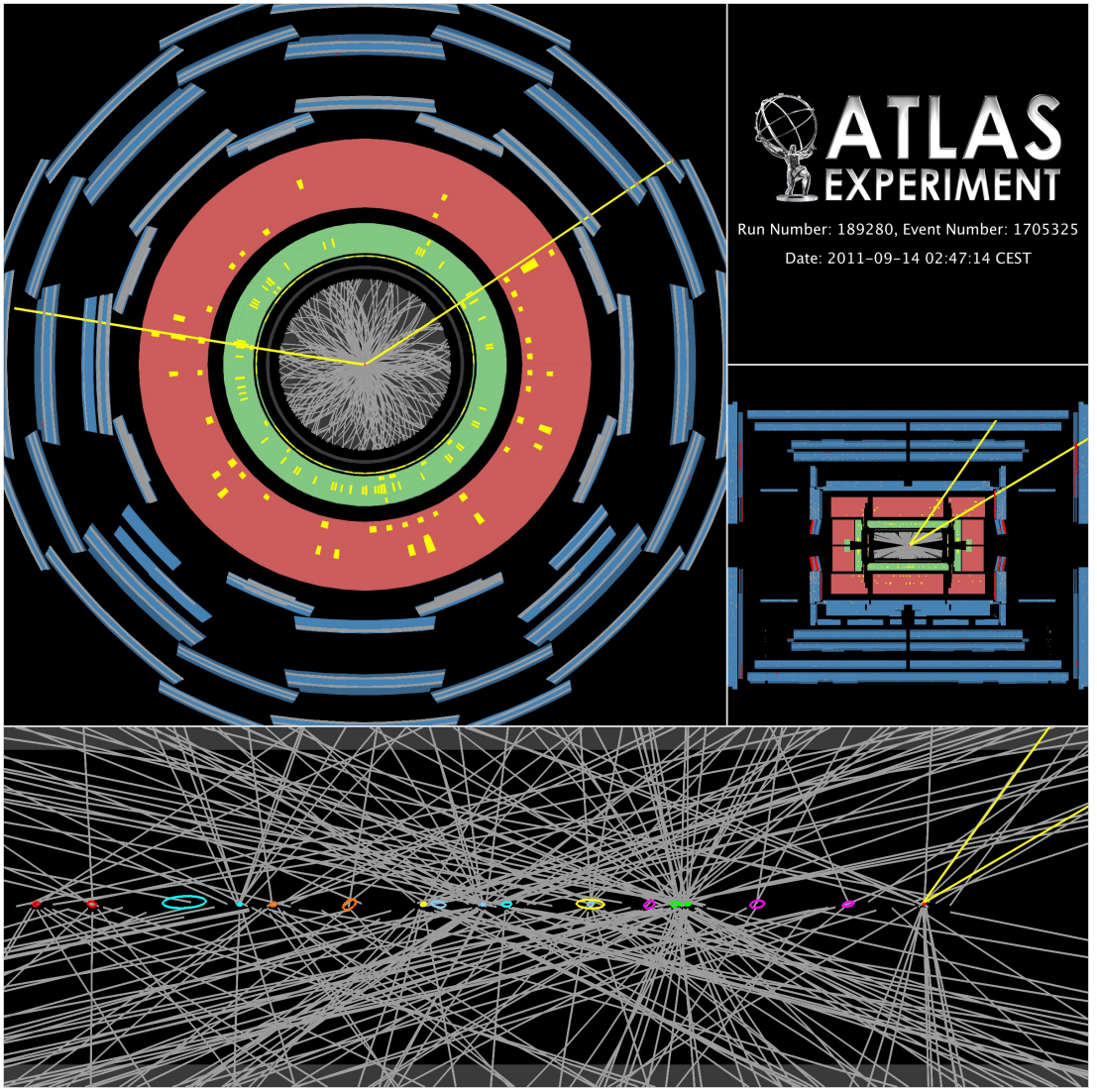
Organization
- US Involvement

TDAQ Upgrade Overview

Status & US Contributions
- L1Calo
- HLT/DAQ
- Phase 2 Planning

Budget Details & Effort

Conclusions



A taste of what's to come (event with 20 vertices)

US TDAQ Upgrade Organization

4.6	TDAQ Upgrade	
4.6.1	LVL1 Trigger	
4.6.1.1	Calorimeter	BNL, MSU, SMU
4.6.1.2	Muon	*no current US participation in L1Muon trigger Phase I upgrade*
4.6.1.4	Track	Phase II: Indiana, LBNL, Penn, Yale + *FTK groups*
4.6.2	FTK	Argonne, Chicago, Illinois, NIU, (Fermilab)
4.6.2.1	Engineering design/Prototyping	
4.6.3	HLT/DAQ	Argonne, Irvine, MSU, SLAC, Wisconsin
4.6.3.1	Software Development	
4.6.4	Simulation	Argonne, BNL, Chicago, Indiana, MSU, NIU, Penn, SLAC, SMU, Yale
4.6.4.1	Software Development	
?	AFP	Oklahoma State, Stony Brook, UNM, UTA

Overlap with Other Efforts

- Level-1 Calorimeter Electronics, New Small Wheel Electronics
- M&O HLT & DAQ work
- Separate FTK, AFP
- Simulation Demers (Yale), Linnemann (MSU)

TDAQ Upgrade Overview

Phase 1

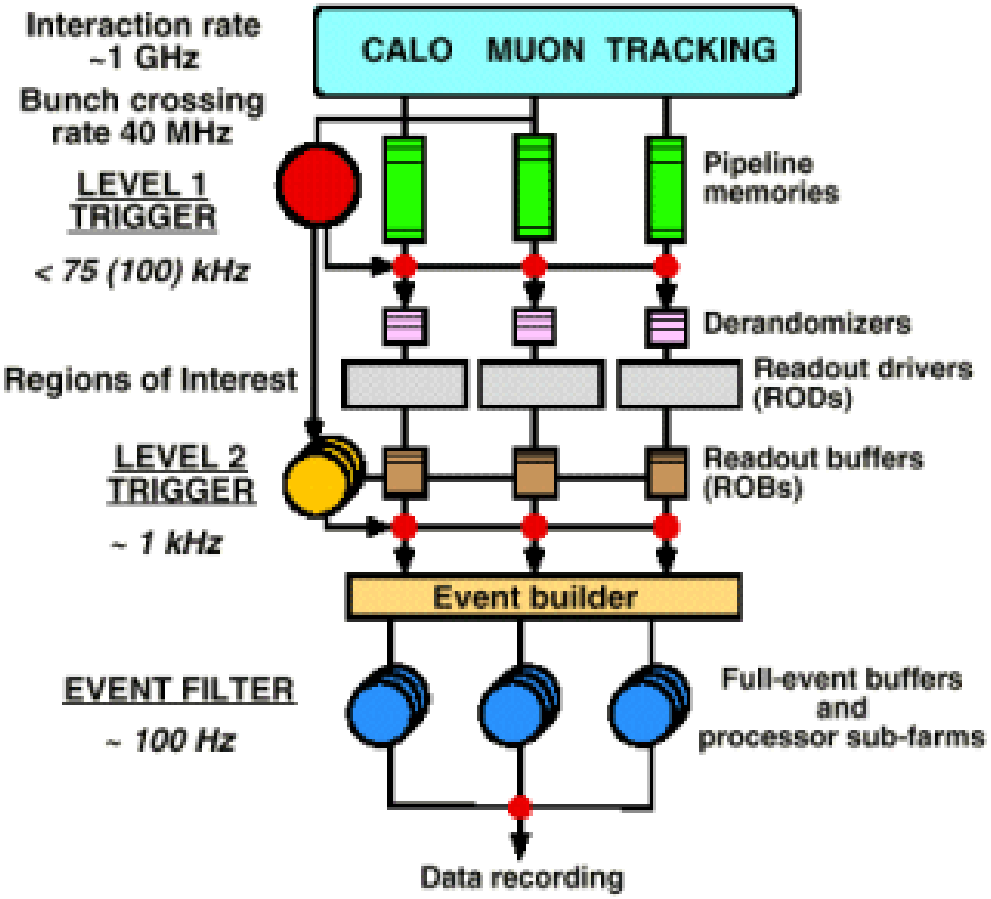
- L1 Calorimeter Trigger
  - > EM granularity, topology
- L1 Muon Trigger
  - > New Small Wheel info
- Fast Tracker Trigger (FTK)
  - > track info at start of L2
- HLT (L2, EF) & DAQ
  - > Hardware: ROI build (ROIB)
  - > Software: architect. & algos
- ATLAS Forward Proton (AFP)
  - > L1, HLT, DAQ

Phase 2

- Level 1
  - > Digital Calo, Track?, Muons?
- HLT/DAQ
  - > architecture

Simulation

Current TDAQ System



	Now	FY15-17		Ph-1	Ph-2
Peak Lumi	3×10^{33}	1×10^{34}	1×10^{34}	$2\text{-}3\times10^{34}$	7×10^{34}
Bunch Sep.	50 ns	25 ns	50 ns	25 ns	25 ns
<Int's/x'ing>	12	25	50	50-80	230

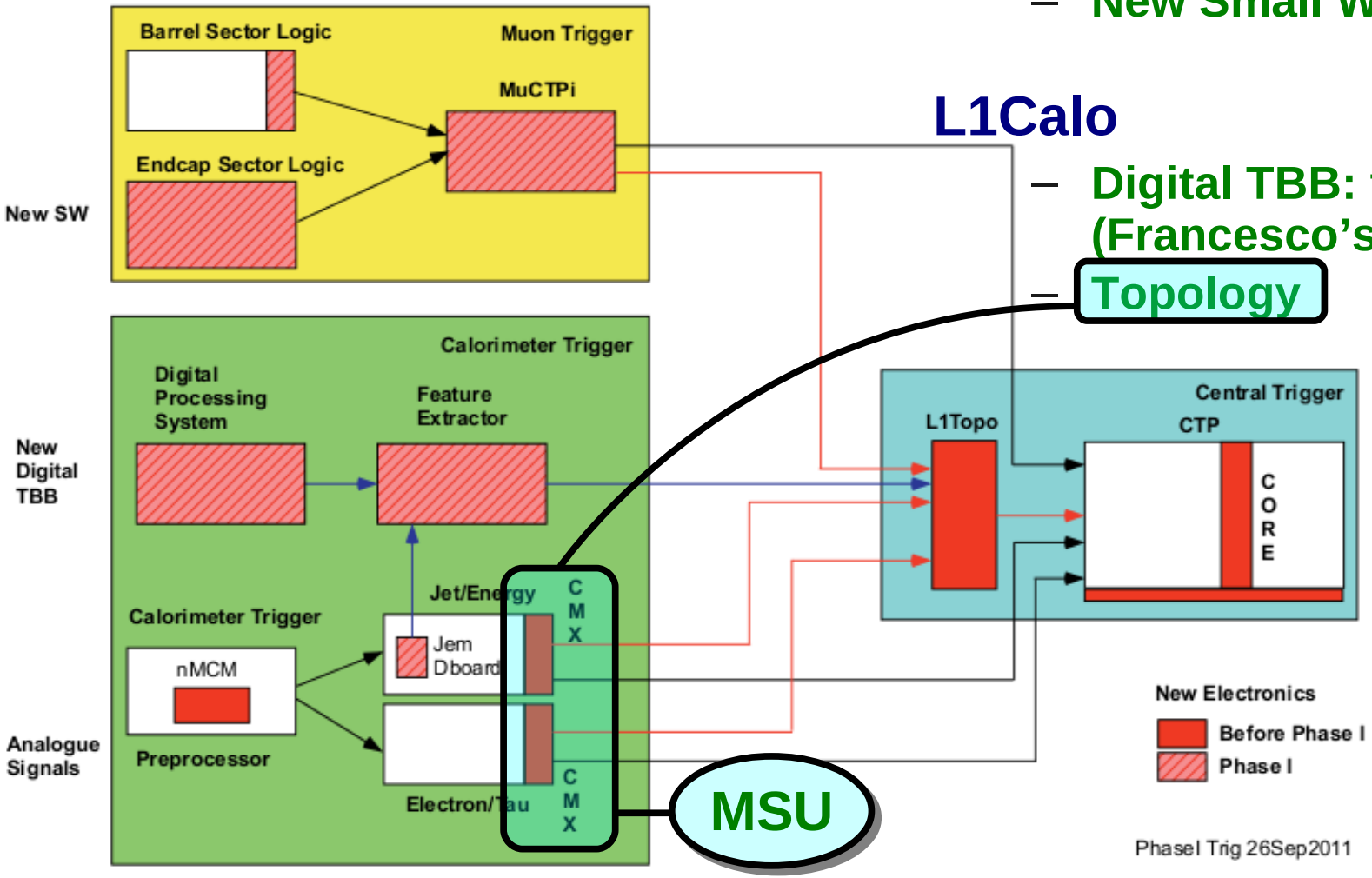
Level-1 Trigger System: Phase 0/1

L1Muon (Vinnie's talk)

- New Small Wheel Inputs

L1Calo

- Digital TBB: finer EM granular. (Francesco's talk)
- Topology



AFP (Andrew's talk)

L1Calo: Topology

Goal: multi-obj. correlations

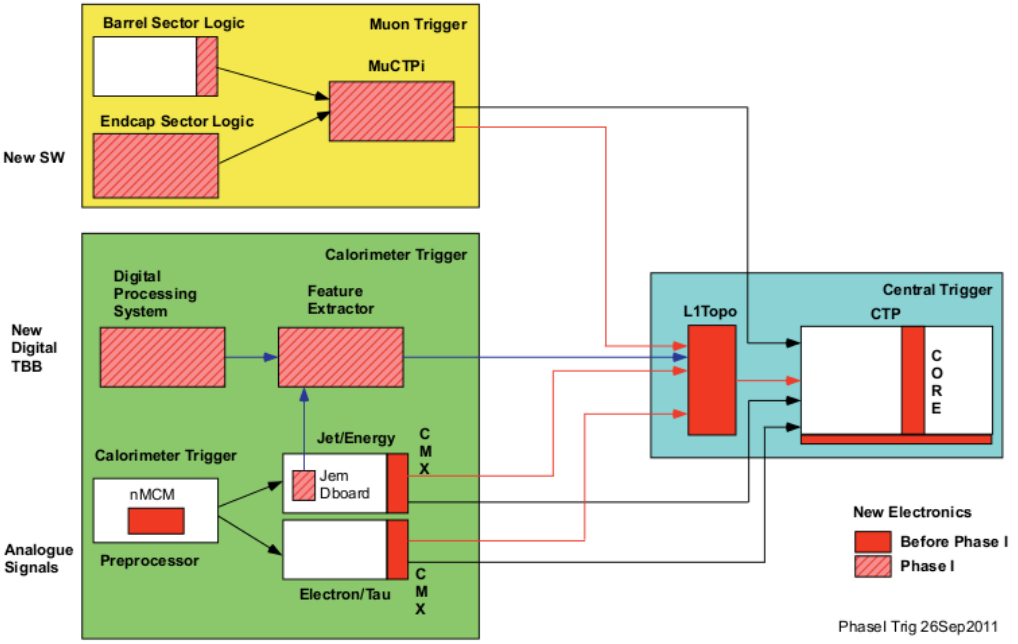
- H_T, M_{ij}, muon isolation, ΔR,...
  - > complex, multi-obj. decays (SUSY,...)
- make L1 ROI η,φ & E_T available
  - > currently just object counts

Hardware Solutions (Phase 0)

- CPM, JEM backplane speed
  - > 40 → 160 MHz (firmware)
- Upgrade CMM → CMX
  - > distributes data to CTP & Topo
- Topological Processor
- CTP: new inputs

US involvement

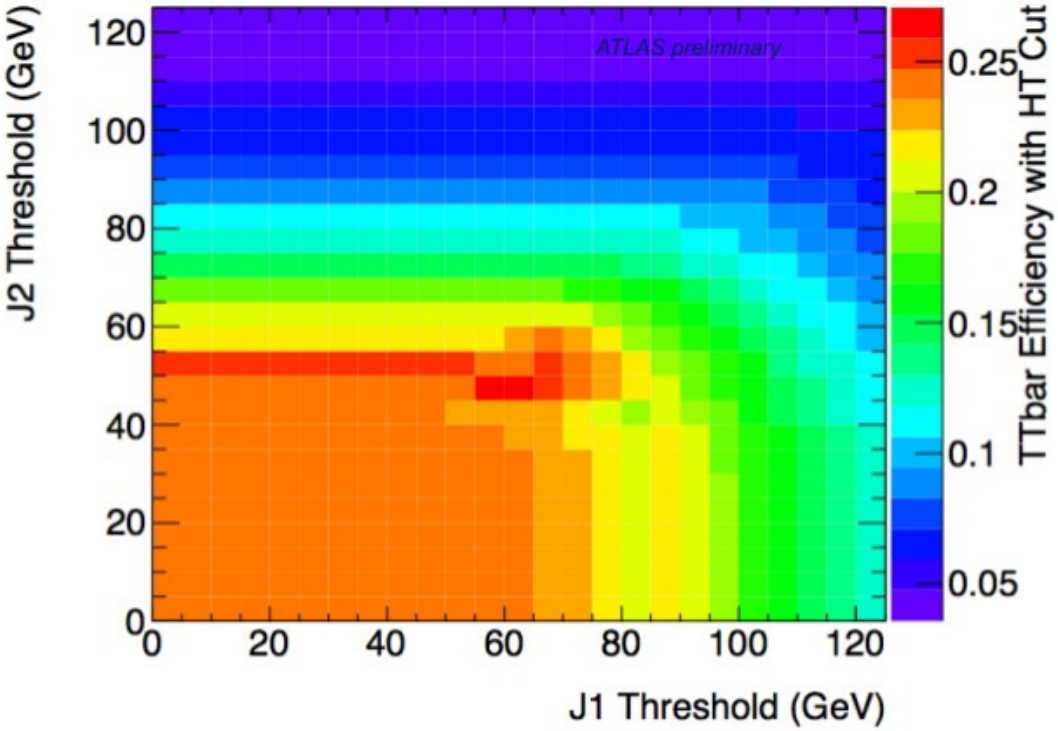
- MSU: CMX, simulation
- BNL, SMU: simulation



CMX Functionality

- obj counts and E_T sums → CTP
  - > as in current CMM
- ROI positions & E_T's → L1Topo
  - > new function

L1Calo: Example Topological Gains



Dijet Trigger Thresholds in Generic t-tbar Events

- example complex state
- can reduce thr's using H_T cut
  - > H_T = Σ object E_T
- H_T less sensitive to pileup than summed cluster E_T

L1 Trigger	t-tbar Eff.	Rate
(J1,J2) > (85,60) GeV	19.7%	5 kHz
(J1,J2) > (75,65) GeV	19.7%	5 kHz
(J1,J2) > (55,45) GeV & H_T > 180 GeV	27.1%	5 kHz

L1Calo: CMX Integration into ATLAS

Strong support for MSU from ATLAS TDAQ management

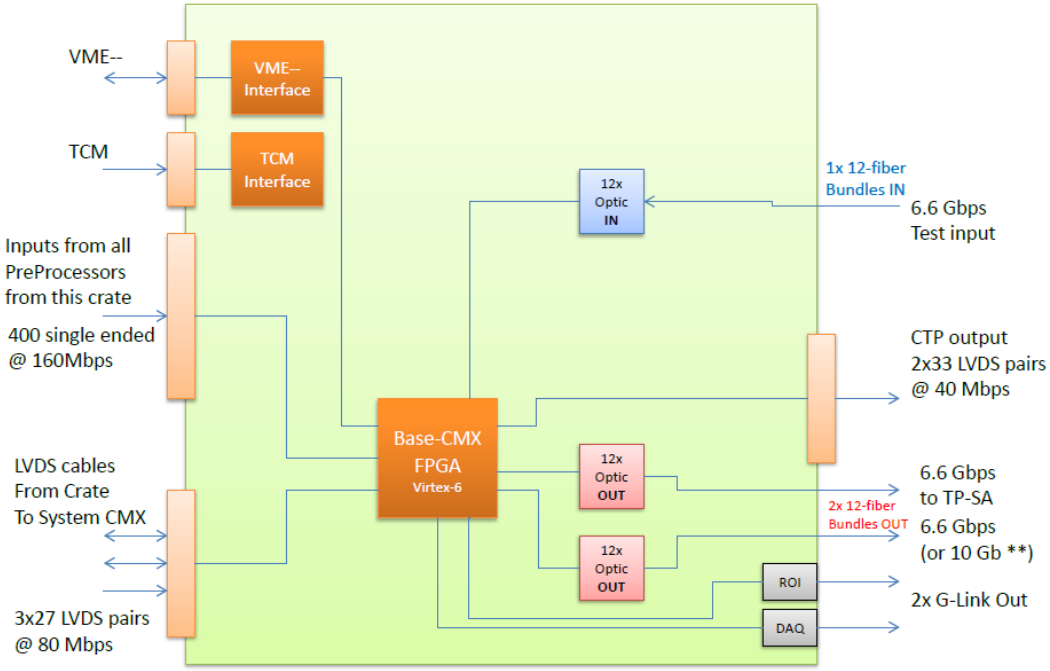
- letter from TDAQ managers Chris Bee & David Francis
  - "We would like to stress our complete support for the MSU team in this project and underline its major importance for ATLAS both in the short and longer terms. We therefore encourage you to strongly support funding requests for this project in future US-ATLAS funding discussions."

CMX Preliminary Design Review (ATLAS internal)

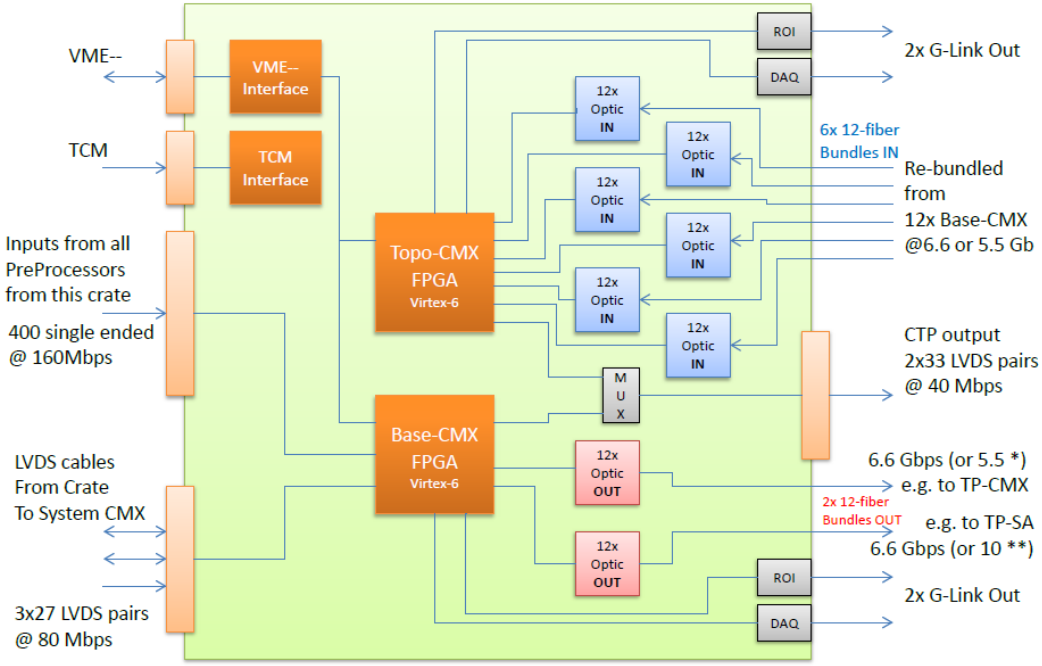
- 29 June, 2011 at Stockholm Level-1 Upgrade Workshop
  - https://indico.cern.ch/conferenceDisplay.py?confId=144624
- "unanimous approval" of CMX project
  - "The Review Committee voted unanimously to approve the CMX project described in the PDR report, pending a number of amendments and actions described below. The members of the CMX design team were thanked for preparing clear and well-written documentation and presentations, which contributed to a smooth and comprehensive review.
    The Committee was of the opinion that given the clear challenges already facing the ATLAS trigger with increasing luminosity, that the CMX is a key item, and that the project is time-critical.
    The Committee also anticipates that ATLAS TDAQ management will soon establish an integrated hardware trigger upgrade project, of which the CMX and its developers will be a part."

L1Calo: CMX Design Status

a) Minimal Option: data to TP



c) TP capability on separate FPGA



Current Effort

- design of control/monitoring/configuration section
- exploring functionality options
  - > limited topological capabilities on CMX
    - · fleshing out several different options to span parameter space
  - > increased data-xmit rates for non zero-suppressed data (6 → 10 Gbs)
- meeting at RAL this week to discuss these options

L1Calo: MSU Effort

CMX Timeline

2012: Q1	Q2	Q3	Q4	2013: Q1	Q2	Q3	Q4	2014: Q1	Q2	Q3
layout			prototype fabrication	depth testing			final fab/ testing	install / test / commission		

– **FY15-17: begin work for Phase 2 L1Calo**

Budget & Effort

	FY13	FY14	FY15	FY16	FY17
Total $	**400.0**	**535.0**	**100.0**	**70.0**	**70.0**
Labor $	311.7	327.3	97.0	70.0	70.0
Material $	80.0	148.0	0.0	0.0	0.0
Travel $	8.3	59.7	3.0	0.0	0.0
EE FTEs	**2.25**	**2.25**	**0.65**	**0.40**	**0.40**

HLT/DAQ in Phase I

HLT Software Changes

- increased use of multi-object and topological triggers
- optimize steering code
- include IBL, FTK, and NSW info
- upgrade TDAQ dataflow infrastructure
  - > combine L2/EB/EF functionality into same processor

UCI

DAQ Changes

- possible data transmission changes
  - > higher bandwidth ROD-ROS readout link (?)
  - > dataflow network to 10 Gb/s ethernet
- redesign ROBIN (move away from PCI-X)
- RoIB changes to deal with higher lumi & new inputs
  - > commercial server or mod's to existing VME system

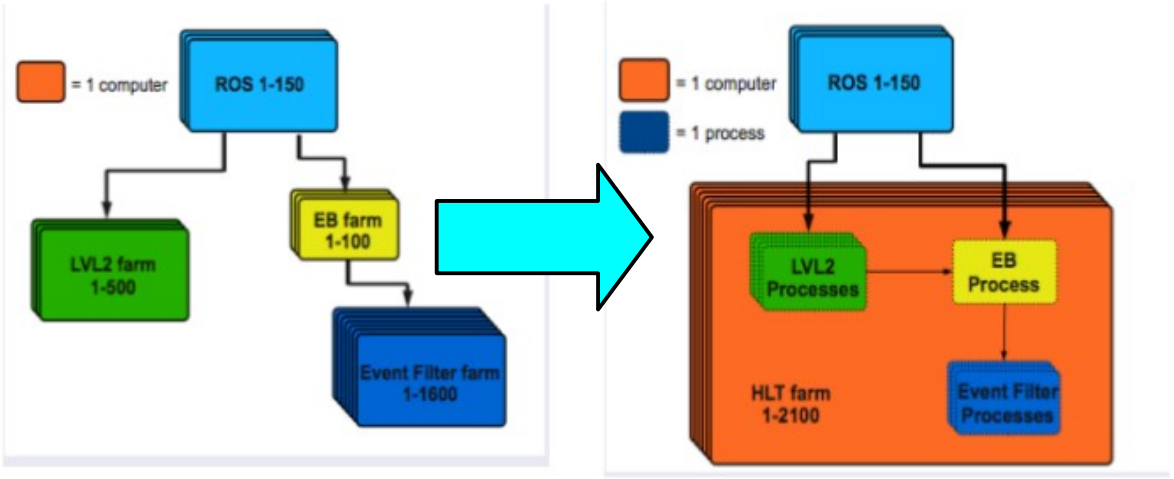
ANL

- additional DAQ hardware for new systems: RODs, ROSs, ROLs,...
  - > New Small Wheels
- normal software evolution

Phase 1 HLT/DAQ: US Contributions

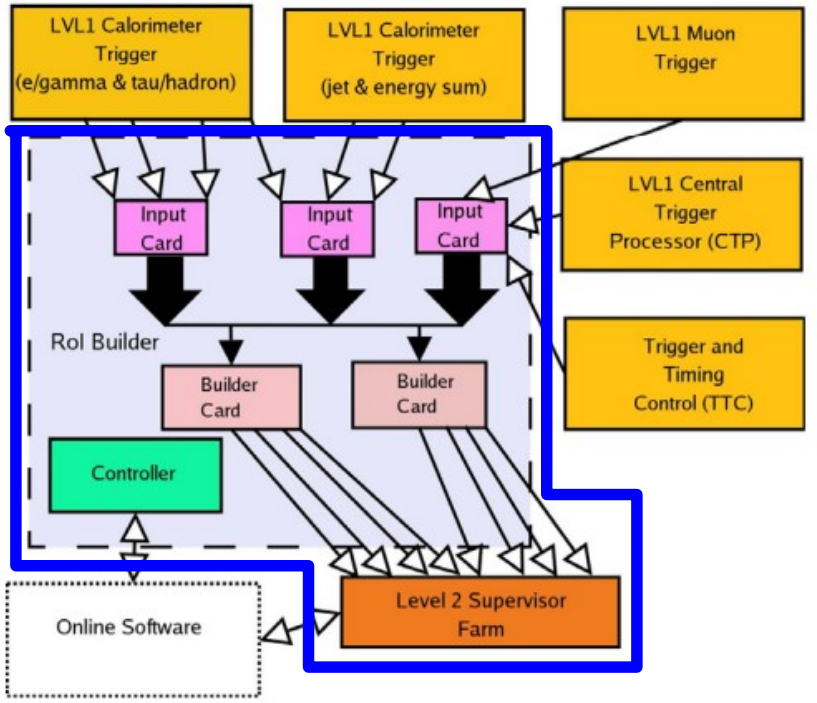
Dataflow (Irvine)

- simplify transmission
- reduce bottlenecks
- L2 & EF proc's on same computer



ROI Building (Argonne)

- merge ROIB & L2 Supervisor
- use commercial server
  - > software revamping
  - > commission new input cards
- upgrade existing VME system
  - > similar level of work as above



HLT/DAQ: US Effort

Timeline

Effort	Inst.	FY12	FY13	FY14	FY15	FY16	FY17
Dataflow	UCI	M&O	M&O	M&O	evaluate/redesign		
RoIB	ANL	evaluate	test	build/install			

Budget & Effort

	FY13	FY14	FY15	FY16	FY17
ANL: RoIB					
Total $	**20.0**	**190.0**	**20.0**		
Labor $	9.5	14.0	12.5		
Material $	5.5	166.0	0.0		
Travel $	5.0	10.0	7.5		
EE FTEs	**0.03**	**0.06**	**0.05**		
UCI: Dataflow					
Total $			**110.0**	**110.0**	**110.0**
Labor $			110.0	110.0	110.0
Material $			0.0	0.0	0.0
Travel $			0.0	0.0	0.0
CP FTEs			**1.00**	**1.00**	**1.00**

Phase 2 Directions

Level-1 Trigger System

- L1Calo: fully digital readout
  - MSU well-placed to contribute here after CMX
- L1Muon: include precision chambers?
- L1Track (new system)
  - Self-Seeded large impact on Tracker, low impact on Trigger
  - ROI-Based low impact on Tracker, large impact on Trigger

HLT & DAQ

- New system architecture

Timescale

- Phase 2 LOI planned for end of 2012
- but several groups heavily involved in Phase 1 (MSU, ANL, UCI)

TDAQ Upgrade Summaries

Budget (k$)

INSTITUTION	FY13	FY14	FY15	FY16	FY17
ANL	20	190	20		
MSU	400	535	100	70	70
UCI			110	110	110
Total TDAQ	**420**	**725**	**230**	**180**	**180**
Total TDAQ CORE	1495	678	481	1082	1489

Effort (Upgrade-funded FTEs)

INSTITUTION	FY13	FY14	FY15	FY16	FY17
ANL	0.03	0.06	0.05		
MSU	2.25	2.25	0.65	0.40	0.40
UCI			1.00	1.00	1.00
Total TDAQ	**2.28**	**2.31**	**1.70**	**1.40**	**1.40**

Impact of Low Guidance

reduction (k$)	FY13	FY14	FY15	FY16	FY17	Impact
ANL	0	50	0			material purchases
MSU	30	75	60	40	40	labor – high risk to design & implementation
UCI			40	40	40	labor – reduced impact
Total TDAQ	**30**	**125**	**100**	**80**	**80**	

Conclusions

US involvement in Phase 0/I TDAQ upgrade

- L1Calo
  - MSU responsible for design/construction of CMX
- HLT/DAQ
  - ANL: new RoIB; UCI: dataflow upgrade
- Simulation
  - US groups playing a leading role here
- Much of this aimed at FY13/14 shutdown (LS1)
- Overlap with other efforts not covered here
  - AFP, FTK, New Small Wheels, LAr electronics

Phase 2 Planning Started

- some US effort, but main focus is Phase 1

Backup Slides

L1Calo: Single EM Changes

Goal: maintain low single-EM E_T thresholds

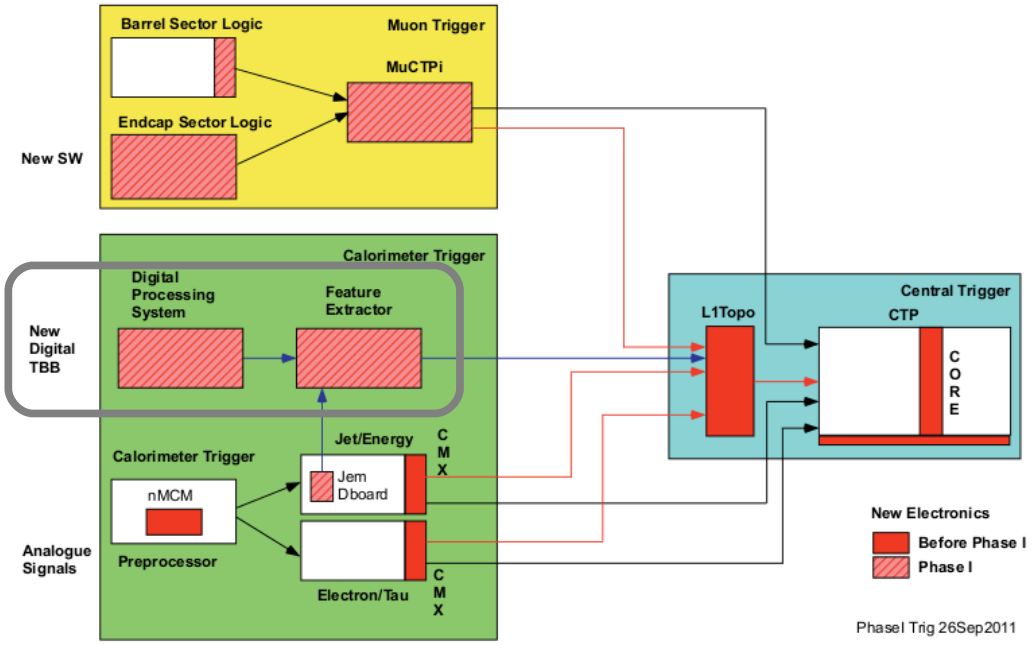
- W's & Z's (W/Z H), SUSY,...

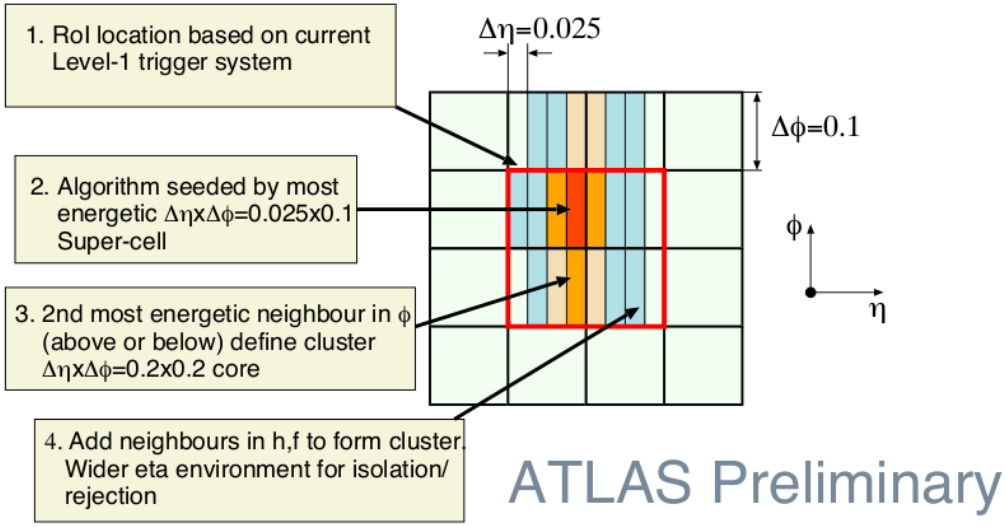
Hardware Solutions

- finer granularity at EM Layer 2
  - > digital info from LAr (TBB)
  - > L1Calo: DPS, FEX
  - > $R_\eta = E_{3x7} / E_{7x7}$
- HCal TT quantization
  - > 1 GeV → 250 MeV
  - > *hadCore* ≤ 750 MeV

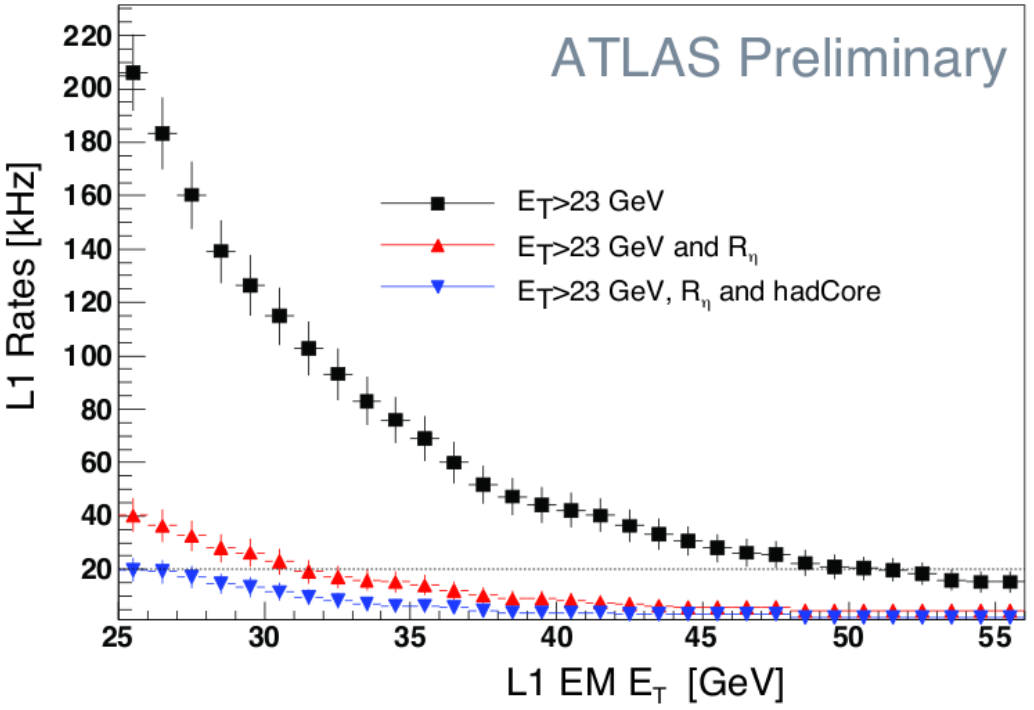
US involvement

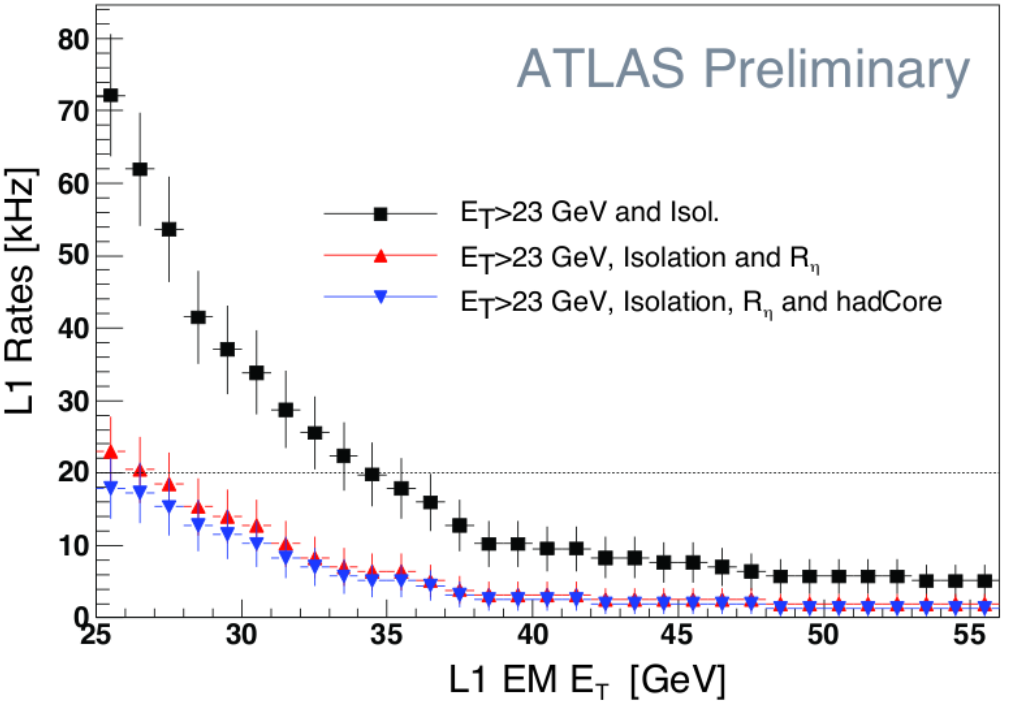
- MSU, SMU
- simulation/algo development





L1Calo: Single EM Gains





R_η	e Eff ($Z \rightarrow ee$)	Jet Rej Eff MC	Jet Reg Eff 2011 data
0.939	99.51%	56.7%	51.2%
0.951	99.04%	60.6%	57.4%
0.956	98.47%	63.0%	59.7%

L1 Trigger	Eff(WH)	Rate
E_T^{EM} > 35 GeV	73%	54 kHz
& Isolation	71%	16 kHz
& R_η > 0.94	71%	6.5 kHz